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Navigating collaborative networks and cumulative effects for Sustainable Seas

Kathryn Davies[a,*], Karen Fisher[b], Melissa Foley[c,1], Alison Greenaway[d], Judi Hewitt[a], Richard Le Heron[b], Harry Mikaere[e], Kelly Ratana[a], Roseanna Spiers[b], Carolyn Lundquist[a,b]

[a] National Institute of Water and Atmospheric Research, PO Box 11115, Hillcrest, Hamilton 3251 New Zealand
[b] University of Auckland, Private Bag 92019, Auckland, 1142 New Zealand
[c] University of California, Santa Cruz Institute of Marine Sciences, 1156 High St., Santa Cruz, CA 95064 United States
[d] Landcare Research, Private Bag 92170, Auckland Mail Centre, Auckland, 1142 New Zealand
[e] HR Mikaere Ltd., 668 Marae Rd RD1, Coromandel New Zealand

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ABSTRACT

Cumulative effects in the marine environment increase the risk of environmental, economic or social collapse because the combined effects of new and existing marine industries, climate change and other stressors are often not accounted for in the determination of environmental capacity. Ecosystem-based management and the development of tools that translate complex social-ecological processes into dynamic, adaptable management strategies are needed to avoid these pitfalls. Previous work has highlighted disconnects between how cumulative effects are interpreted and assessed by science agencies, funding agencies, and management agencies, but has largely missed how investors are interpreting them. These social-ecological boundary and threshold issues illuminate the pivotal challenge of institutional change and agency behaviors that are needed to address cumulative effects. Using scenario planning techniques, a team of researchers from the Sustainable Seas National Science Challenge in Aotearoa New Zealand engaged key decision makers and stakeholders in creative thinking and constructive conversation aimed at bridging some of these institutional and behavioral disconnects. A range of different strategies regarding how to address cumulative effects were proposed by the assembled participants, but the need for collaborative networks that enable collective thought and action across boundaries was emphasized throughout the day. This paper explores the themes that emerged and some of the barriers that must be addressed to facilitate bold action on the topic of cumulative effects.

Ki te kahore he whakakitenga ka ngaro te iwi – Without foresight or vision the people will be lost.

1. Introduction

Human and natural stressors accumulate in the environment and have cumulative effects (CE) on mountains, rivers, oceans, and the human systems that rely on them for health and well-being (Foley et al., 2017; Halpern and Fujita, 2013; Rudd and Fleishman, 2014). In particular, the CE of stressors such as new and existing marine industries and climate change have contributed to a rapid decline in ocean and coastal resources (Halpern et al., 2008; Kaplan et al., 2013), overwhelmed our ability to set appropriate marine resource targets and limits (Duinker et al., 2013), and increased the risk of environmental, economic, or social collapse (Scharin et al., 2016).

Cumulative effects analyses aim to manage and reduce the CE of human activities on coastal and marine ecosystems, but in the current state of practice, science and policy frequently do not align (Duinker et al., 2013; Foley et al., 2017; Prahler et al., 2014). Meanwhile, the role of economics and investment in the management of CE is often overlooked. Instead, CE tend to be defined differently in science and legal mandates, across different sector-based management policies, and are implemented inconsistently by practitioners due to a lack of clear definitions and a plethora of implementation challenges. Managing CE is also hindered by the interpretation and assessment of key elements such as scale (Therivel and Ross, 2007), impacts (Canter and Ross,

* Corresponding author.
E-mail addresses: Kate.Davies@niwa.co.nz (K. Davies), k.fisher@auckland.ac.nz (K. Fisher), melissa.foley@aucklandcouncil.govt.nz (M. Foley), GreenawayA@landcareresearch.co.nz (A. Greenaway), Judi.Hewitt@niwa.co.nz (J. Hewitt), r.leheron@auckland.ac.nz (R. Le Heron), hr.mikaere@xtra.co.nz (H. Mikaere), Kelly.Ratana@niwa.co.nz (K. Ratana), roseanna.spiers@auckland.ac.nz (R. Spiers), Carolyn.Lundquist@niwa.co.nz (C. Lundquist).
[1] Present address: Auckland Council 135 Albert Street Auckland 1142 New Zealand.

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2010), significance (Schultz, 2010), and baseline conditions (Prahler et al., 2014). For the purposes of this research, cumulative effects (CE) were defined broadly as stressors that overlap in space and/or time (e.g. environmental, economic, social).

These general challenges, along with location-specific issues in Aotearoa New Zealand (Aotearoa NZ) associated with fragmented science, management and governance (Lundquist et al., 2016; Thrush et al., 2016), diverse social values (Bremer and Glavovic, 2013), competing interests and power struggles (Bess, 2010), and capacity (McGinnis, 2012) all contribute to a daunting implementation puzzle. Current disconnected frameworks leave coastal and marine social-ecological systems in Aotearoa NZ vulnerable to rapid changes or tipping points, which can be difficult to predict because of variations in stressor responses, recovery times, interactions (e.g. synergistic, antagonistic), and surprise. These disconnects highlight the pivotal challenges of institutional and behavioral change that are needed to address CE in coastal and marine areas.

Ki uta ki tai—from the mountains to the sea—is an indigenous Māori concept that emphasizes the interconnectedness of ecosystems inclusive of people (Tipa et al., 2016). Most recently, a call for ki uta ki tai approaches to CE has come out of collaborative research undertaken by the Sustainable Seas National Science Challenge[2] (SSNSC), a large-scale, government-funded, mission-led research program. At the center of SSNSC is a commitment to ecosystem-based management (EBM), an integrated approach to oceans that emphasizes the maintenance of ecosystems and human well-being over sectoral management. At a workshop in August 2016, a team of researchers, government authorities, indigenous Iwi (tribes)/Māori, interest groups, and industry and youth representatives gathered to investigate possible management and governance strategies that could address CE across multiple scales and from multiple sectors. This paper explores the themes that emerged from our discussions and some of the barriers impeding bold action on CE.

2. Context and background

2.1. Regulatory frameworks and cumulative effects in New Zealand

At present, coastal and ocean management in Aotearoa NZ is covered by 25 statutes governing 14 agencies and operating across seven spatial jurisdictions (Bremer and Glavovic, 2013). Under the Resource Management Act 1991 (RMA), responsibility for the sustainable and integrated management of marine natural resources in the territorial sea (12 nautical miles) is devolved to regional and district councils. Sustainable management of natural resources within the exclusive economic zone and on the continental shelf (from 12 to 200 nautical miles) is regulated by the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act (EEZ Act) 2012. Activities not covered by these two acts include fisheries, maritime transport, submarine cables, and marine reserves; these activities are addressed under a variety of other Acts. However, because stressors cross political boundaries, and interpretations of CE, if considered at all, are different under each of these governance and management regimes, the integrated approach promoted by the RMA is largely superficial (Van Roon et al., 2016). Central government support for RMA implementation, coordination, and collaboration across all levels of government is needed to address CE in the marine environment (Bess, 2010), but first a shared understanding of what CE are and what should be done is needed.

2.2. Mātauranga Māori and cumulative effects in Aotearoa

Another key feature of resource management in Aotearoa NZ is the role of indigenous Iwi/Māori as partners with the Crown under the Treaty of Waitangi, widely considered the founding document of the country. According to the Treaty and contemporary resource management regulations, tāngata whenua (local indigenous people) have the right to exercise kaitiakitanga (Māori stewardship according to their own aspirations and practices), and therefore Māori have the right to be included in planning and decision making for natural resources through co-management and co-governance arrangements (Webster and Cheyne, 2017). These arrangements present opportunities for both mātauranga Māori (Māori indigenous knowledge systems) and scientific knowledge to contribute to the evolution and enhancement of sustainable management goals and practices. A key contribution that mātauranga Māori offers for managing CE is a place-based understanding of environmental change. This understanding is derived from intergenerational observations and the transmission of that knowledge (see Appendix A for the karakia (incantation) that opened the workshop). Mātauranga Māori also offers a holistic world view that emphasizes relationality, interconnectedness, and the cultural and metaphysical dimensions of place. Changes in the natural environment and the relationships between humans and their environment have been recorded through oral histories, whaikōrero (speeches), whakataukī (proverbs), waiata (songs), and whakapapa (genealogy).

2.3. Social-ecological challenges of cumulative effects

Cumulative effects can be caused by multiple activities overlapping in time and/or space, or they may be caused by a single activity that generates multiple stressors. For example, bottom fishing removes specific size classes of fish but can also increase sediment in the water column, destroy habitat structure, and change sediment characteristics (Thrush and Dayton, 2002). As the number of activities in marine systems increases, our understanding of the effects of multiple stressors is refined and increased occurrences of abrupt social-ecological system shifts are documented. This can lead to previously agreed upon levels of activities becoming unacceptable Scientists, managers, and others are now increasingly recognizing the need to work at the level of social-ecological systems, where responses to stressors may be non-linear and surprises can cascade (Crépin et al., 2012; Thrush et al., 2016). In this paradigm, managing for resilience and implementing governance structures that deal with surprises has gained both relevance and urgency (Bennett et al., 2015; Serrao-Neumann et al., 2016).

Furthermore, the management of CE is frequently troubled by perceived conflicting interests (e.g., urban expansion versus ecosystem restoration) and high stakes outcomes. Incorporating a range of interests and values into marine management and governance is also complicated by the urgency and reactionary nature of decisions being made. In coastal and marine areas, conflicting practices and values often overlap in a relatively small geographic space, but values are largely ethereal when considered in relation to practices, and may therefore be more easily overlooked in decision making. Some experts suggest that values attributed to ecosystems and their associated goods and services depend on the stakeholders who are in a position to benefit or understand (Hein et al., 2006; Stephenson, 2008), raising questions about equity and social justice.

2.4. Scenario planning techniques

The SSNSC, which focuses research on social-ecological systems within an EBM framework, provides an ideal setting for progressing work on CE. To encourage researchers and research participants to connect across interests, disciplines, cultures, and other boundaries, we utilized scenario planning techniques at a SSNSC-funded workshop. Scenarios are plausible, alternative stories of possible futures, increasingly utilized to address complex problems such as climate change with diverse groups of participants (e.g., IPCC, 2000). Scenario planning can provide an internally consistent, structured exploration of CE

[2] www.sustainableseas.co.nz.

management; help assess trade-offs and the implications of alternative futures for today's decisions (Peterson et al., 2003); and identify triggers for change (e.g. Johnson et al., 2012). We used these techniques to discuss CE in Aotearoa NZ and how gaps in definitions, interpretation, and application could be bridged.

3. Methods

The six scenario stories utilized for this workshop were socio-political scenarios set in 2050. Scenarios were derived from previous work on biodiversity conservation and climate change[3] and repurposed for this research. Research team members worked together prior to the workshop to tailor the existing scenarios to be more relevant to CE based on previous research and experiences working with CE. Fisheries, biophysical processes, and social, cultural, and economic strategies that would potentially produce a range of CE management and governance options were highlighted.

3.1. Workshop details

The one-day scenario planning workshop involved a diverse group of 44 people (Table 1)[4]. In advance of the workshop, participants were given a copy of the workshop agenda and a short introductory article on the topic of cumulative effects (i.e., Mach et al., 2015). On the day, participants were briefly introduced to the concept of CE and the agenda by four members of the research team (a social scientist, a marine ecologist, a statistician, and a Māori researcher), who set the scene, introduced the SSNSC, described some of the social-ecological challenges of CE, and discussed the relationship between mātauranga Māori and CE.

Participants were organized into six groups comprised of individuals with different expert knowledge and interests who stayed together for the day. Groups typically included at least one representative of central government, regional government, industry and the research team. Māori interests, youth interests, environmental organizations and other miscellaneous participants were allocated across groups to maximize diversity of expertise and geographies of participants represented. Every group included a facilitator from the research team and a note-taker. The workshop was divided into three scenario breakout sessions; in the first two sessions, participants were asked to imagine that they were an informed actor in 2050 who was trying to address CE. Questions for the three breakout sessions were developed to encourage participants to consider what is needed, what is possible, and who might be involved in developing actions to address CE (see Appendix B for a complete list of questions). The challenge of who ought to lead the development of a more robust system to manage for future generations was posed to stimulate bold and creative thinking.

In Session 1 participants responded to questions regarding one of three "negative" future scenarios (Fig. 1: Stormy, Kicking or Collapse). In Session 2 participants responded to the same set of questions regarding one of three "positive" future scenarios (Fig. 1: Responsive, Co-adaptive or Techno). After each session, participants reported key points back to the larger group. In Session 3, participants compared and contrasted their previous scenarios and considered how to prepare for a range of possible futures. The workshop concluded with a whole-group discussion.

3.2. Data analysis and reporting

A literature review on the topic of CE was conducted prior to the workshop to establish likely key themes for consideration in scenario stories, data coding, and analysis (Table 2). After the workshop, a summary document was compiled from small group researcher notes, group reporting notes, and research team reflections, and distributed to participants.

Workshop notes were also compiled into a compendium that was coded and analyzed using whole-text analysis (e.g. Miles and Huberman, 1994) in the constructivist grounded theory tradition, which encourages researchers to develop themes for use in the analysis and evaluation of data, but also allows for the emergence of new and unexpected themes (after Charmaz, 2014). To help reflect the centrality of indigenous perspectives and the interconnected nature of the discussions that emerged from the workshop, Martin & Mirraboopa's (2003) theoretical framework for indigenous and indigenist research was adapted for the data analysis phase of this work (Table 2). The framework focuses on understanding and assessing knowledges, values, and actions: actions (ways of doing) are the embodiment of our values (ways of being) and knowledges (ways of knowing) (Martin and Mirraboopa, 2003). QSR International NVivo 11 computer software was utilized to facilitate the coding and analysis of the data. Memoing was used to record the process of emergence and the relationships between themes.

Table 1
Summary of workshop participants.

Stakeholder affiliation	Number of representatives
Central government	7
Environmental organizations	2
Industry (e.g. Aquaculture, Forestry, Oil & Gas, Fisheries, Mining)	6
Māori interests	4
Miscellaneous interests and actors	6
Regional/local government	7
Research team	8
Youth interests	4
Total number of workshop participants	44

4. Results

4.1. Overview of workshop session results

A total of 70 topic categories (topics of discussion or nodes) emerged from the literature review and workshop data, and 988 references (comments that related to these categories) were coded to these categories from six primary data sources (notes from the six working groups) (see Appendix C for a complete list). Overarching themes developed from the literature review were frequently discussed at the workshop, but additional and re-framed themes also emerged (Table 2).

A diversity of topics with respect to CE were discussed by the six groups in each session, reflected by the most commonly referenced topics discussed by the six groups in each session, and topic categories that received 15 or more references across all sessions (Table 3). Four categories were referenced in all three breakout sessions: "Shared vision, goals and values", "Adaptive", "Economics," and "Regulation". "Shared vision, goals and values" was the most frequently mentioned category in all three sessions (n = 52 references); the number of references for other categories varied across sessions.

4.2. Breakout session 1: negative future scenarios (stormy, kicking and collapse)

In Session 1 the top ten referenced categories were similar across all six breakout groups (Table 3). Discussions predominantly focused on categories representative of either *how* they arrived at the "negative"

[3] http://ccii.org.nz/.

[4] Procedures were approved by the University of Auckland Human Participant Ethics Committee and performed in compliance with relevant human research ethics laws and institutional guidelines.

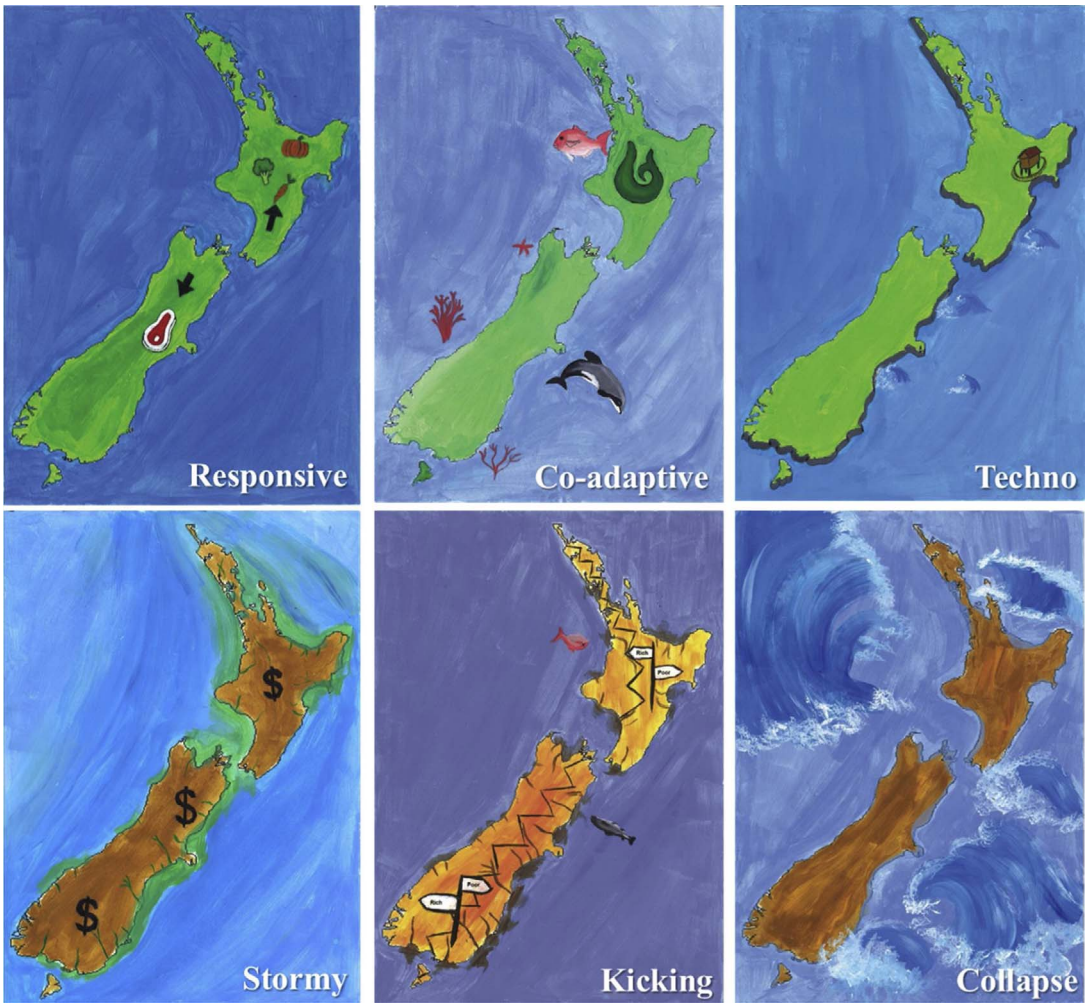

Fig. 1. Images that accompanied the six scenario descriptions. *Responsive:* characterized by significant mitigation of CE, global growth, and strategic exploitation. *Co-adaptive:* characterized by global connectivity, sustainability, and ambitious national mitigation of CE. *Techno:* characterized by ambitious global mitigation of CE, this cohesive rich world is focused on economic gain. *Stormy:* characterized by little mitigation of CE, global growth and few local benefits. *Kicking:* characterized by fragmentation, mitigation of CE through power blocks, and social inequality. *Collapse*: characterized by no mitigation of CE and degraded coastal and marine areas, this is a fragmented world with increasing social disparity. Graphics created by Samira van Hunen.

Table 2
Development and adaptation of key research themes.

Themes from literature review	Examples
Scientific assessment and decision making	Spatial and/or temporal scales, baselines/ monitoring, uncertainty, significance
Collaboration	Among agencies, iwi/Māori and stakeholders, as well as science, policy and management
Management approaches	Adaptive management, integrated catchment management, ecosystem-based management

Coding themes (adapted from Martin and Mirraboopa, 2003)	Examples
Knowledges	Data and information (including baselines, monitoring); scale (spatial and/or temporal); uncertainty; indicators; economics; education; mātauranga Māori
Values	Adaptive; collaboration; connectivity; kaitiakitanga; role of science; shared vision, goals, and values; trust
Actions	Behaviour change; group decision-making; institutional change; integrated management, regulation
Emerging opportunities	Alternative industries; co-governance and co-management; Sustainable Seas National Science Challenge

future scenario or what was needed to *avoid* it. All groups discussed the role of regulation as a driver of the negative future scenario, particularly the lack of or poorly implemented regulation, and the need for more and better regulation regarding CE. For example, one regional/ local government representative (Group 3) pointed out that "if people don't know [about CE] because there isn't the regulation, you could see how it [this scenario] is left to happen." All groups also discussed how the lack of adaptive values and strategies associated with regulation contributed to the negative future. One miscellaneous representative (Group 1) pointed out that "we need to be constantly re-evaluating. The

Table 3
Top ten most frequently referenced categories by session (in bold) and most commonly referenced categories by session that have a total of 15 or more references made across all three sessions. Categories run from those with highest total number of references to lowest.

Category	Number of references and number of groups that referenced the category (out of six)			Total number of references (n)
	Session 1	Session 2	Session 3	
Shared vision, goals & values	**17 (5)**	**19 (5)**	**16 (6)**	52
Adaptive	**16 (6)**	**18 (5)**	**6 (4)**	40
Regulation	**12 (6)**	**11 (6)**	**11 (6)**	34
Science, Role of	6 (4)	**16 (5)**	**11 (6)**	33
Economics	**15 (5)**	**11 (4)**	**6 (5)**	32
Integrated management	**12 (4)**	9 (4)	**11 (5)**	32
Connectivity	**11 (4)**	6 (4)	**14 (4)**	31
Collaboration	10 (6)	**10 (6)**	6 (4)	26
Holistic perspective	**13 (4)**	8 (5)	4 (3)	25
National standards	2 (2)	5 (2)	**16 (6)**	23
Social values	6 (2)	**13 (5)**	4 (2)	23
Leadership	9 (3)	9 (6)	5 (5)	23
Behavior change	7 (2)	10 (6)	5 (4)	22
Intergenerational thinking	**11 (4)**	6 (3)	2 (2)	19
Climate change	10 (5)	6 (3)	3 (3)	19
Trust	5 (4)	9 (4)	5 (3)	19
Integrated governance	11 (4)	3 (2)	5 (2)	19
Education	5 (3)	9 (5)	4 (2)	18
Political system	8 (4)	6 (5)	4 (3)	18
Investment in science & technology	3 (2)	**11 (4)**	3 (3)	17
Institutional change	2 (2)	4 (2)	**11 (5)**	17
Uncertainty	**11 (5)**	5 (2)	1 (1)	17
Intensive industries	**13 (5)**	2 (2)	1 (1)	16
Engagement	7 (4)	4 (3)	5 (3)	16
Ownership & Responsibility	9 (4)	4 (3)	3 (3)	16
Incentives	2 (1)	8 (4)	6 (2)	16
Global integration	3 (3)	**10 (4)**	2 (1)	15
Shock, surprise & tipping points	6 (4)	5 (4)	4 (4)	15
Data and information	4 (3)	3 (2)	**6 (3)**	13
Experimentation	2 (1)	**10 (3)**	0 (0)	12

Regional Coastal Plans should be reviewed every 10 years and there should be an opportunity for community input." Most groups discussed the role of economic drivers and intensive industries, such as agriculture, fishing, and forestry in contributing to the negative scenarios. Difficulties in addressing uncertainty in social, ecological, and economic trends were attributed to fragmentation of management and governance, leading down a path to the negative scenarios.

To avoid the negative scenarios, participants identified the need for shared vision, goals, and/or values, adaptive values and strategies, and the need for more holistic perspectives on decision making, often with a focus on long-term planning cycles. A regional/local government representative (Group 1) pointed out that:

I think it's related to a lack of vision or plan. Did we have an understanding of what we wanted to achieve in 2050? We need those future plans and pegs in the ground to say here's the starting point, this is what we aspire to achieve with milestones and goals along the way. We can then look at checkpoints to see the future if we follow our current way; we need a vision plan with overarching shared goals.

Five out of six groups discussed the potential for integrated management to help avoid the negative futures and foster greater connectivity between institutions. Intergenerational thinking was discussed by four out of six groups—to emphasize the need for long-term strategizing, planning, and decision making that takes the well-being of future generations into account. For example, a Māori representative (Group 1) discussed the long history of the Crown's failure to meet its Treaty obligations, and how this was impeding the well-being of future generations:

My tīpuna [ancestors] went to the Crown and were talking about [cumulative effects], and they [the Crown] were blaming the gold miners. Here we are, 150 years later, talking about the same thing. From those conversations to now, things are getting worse. We need to think about future generations—otherwise the same conversation continues.

4.3. Breakout session 2: positive future scenarios (responsive, co-adaptive and techno)

In Session 2, discussions were similar between groups and focused on how to achieve outcomes associated with the "positive" set of scenarios (Table 3). Categories were similar to those discussed in Session 1 in reference to avoiding the "negative" scenarios (e.g., the necessity of shared vision, goals, and values, and adaptive management and governance strategies needed to address uncertainties). Adaptive economies, particularly alternative industries and economic models, were described as necessary for the Session 2 scenarios to be realised. For example, an industry representative (Group 6) pointed out that "we need to put monetary, economic incentives in place. There has to be a strong global environmental market for things like carbon credits; we could possibly create cumulative effects tradeable rights."

Collaboration, social values, and global integration were also described as important components of positive outcomes. The central role of science in the scenarios in Session 2 was emphasized by five out of six groups; participants also frequently mentioned the need to be inclusive of other knowledge cultures such as mātauranga Māori or local knowledge. An exchange in Group 5 exemplifies this perspective:

> Miscellaneous representative: What institutions were allowed to come about [in this scenario]? Surely all this has not happened because we lead in marine science!
>
> Central government representative: Personally, I don't think so – but we could lead via kaitiakitanga and marine science.
>
> Miscellaneous representative: Maybe 'leading' is a fundamental shift in how we view and value knowledge and how we act upon it.

Investment in science, technology, and experimentation were seen as playing important roles in getting to the positive future scenarios. Regulation, (e.g., stronger and clearer policies and plans) was also discussed by all groups as having a key role to play in facilitating the realization of the positive scenarios. An environmental representative (Group 2) pointed out that in the positive scenario "a more robust planning for the environment is in place. You have clear regulation, and you enforce it."

4.4. Breakout session 3: compare, contrast, and create new pathways forward

In Session 3, groups compared and contrasted the two previously discussed scenarios. Categories that emerged from this session generally focused on either finding commonalities or developing specific ideas that would contribute to a positive future for New Zealanders (Table 3). As in the previous two sessions, shared vision, goals, and values topped the list of referenced categories, and was seen as a necessity to unite Aotearoa NZ on a path towards more positive outcomes for society and the marine environment. All groups also discussed the role of and need for connectivity across levels of governance and management to develop pathways forward, most in reference to the science-policy divide, or in drawing connections between land and seascapes. An exchange among Group 2 representatives highlights this point:

Environmental representative: Well, whose job is it? Who is in

charge? In my experience, a lot of science is good but does not link to policy making… Marine spatial planning is trying to link the science more with planning and we need more of this. More holistic approaches are needed.

Miscellaneous representative: Yes, we are too divided, like I'm fresh water you are salty. But terrestrial issues are feeding into the marine environment. They need to come out and start talking to each other.

Some type of integrated management such as marine spatial planning was discussed by five groups, who each emphasized the need to consider multiple sectors in decision making. Adaptive governance, management, and systems were discussed by four groups in this final session.

In discussions of how to achieve movement towards a more positive future, most groups identified the need to change or improve on existing governance or management strategies. All groups articulated the need for increased and clearer regulations, as well as a set of national standards or guidelines that would set the direction for addressing CE in the marine environment. The need for a standardised approach to CE was also generally agreed upon across interest representatives, including industry representatives, as illustrated by this exchange in Group 3:

Industry representative: We have to conduct some kind of review and engagement plan every time we do [any work], which is going a bit far, but there is something in that. So, if you could have a standardised code of conduct [for CE] that people could sign up to, so that you have a standardised set of regulations, that would be a help.

Central government representative: Yeah, it would be great to have streamlined approaches.

This idea of national standards was regularly raised in Session 3 (n = 16), an increase from Sessions 1 and 2 (n = 7). Most groups also discussed the need for institutional changes to address CE in the marine environment. Suggestions included the need for a single and/or an independent institution that is responsible for the governance and management of the coasts and oceans and has the ability to act swiftly to respond to changes in the marine environment or our understanding of it. The role of science was discussed in two ways by all groups. The first was the need for science to contribute to research on CE. The second was the need for the general public to trust in and support scientific efforts, even when those efforts are associated with high levels of uncertainty, because the work is crucial to understanding the complexity associated with CE. Economics were discussed by five groups, primarily in relation to the role of alternative economic models that would support a move away from the over-exploitation of resources. Surprisingly, in the final session there were few references to mātauranga Māori knowledge systems, related Māori cultural values, or the role of Māori, despite the fact that these topics were regularly discussed in Sessions 1 and 2.

4.5. Key knowledge, values, and actions findings

Knowledge, context, education and/or information were consistently described by participants as being needed to understand and make choices about how to manage CE. For example, the need for trustworthy information, gained through consistent monitoring of key indicators and the establishment of baselines was described, as was the need for a better understanding of the appropriate scales at which to conduct research, management, governance and business. These topics were often connected with uncertainty and how to make decisions in the absence of reliable information. The precautionary principle (Dayton, 1998; Fullem, 1995) was offered as a solution by one group, while another pointed out that a framework was needed to connect and make sense of the different types of information already available.

Participants articulated a range of values during the workshop, but agreed that a "positive" future relied on a shared vision, goals, and values. Adaptiveness, collaboration, holistic and intergenerational thinking, leadership, trust, ownership and responsibility, and experimentation, among others, were qualities described as contributing to positive marine futures, though there was some slippage in the dedication to points about holistic and intergenerational thinking and mātauranga Māori as the day progressed (Table 3). The role of science in establishing and maintaining balanced and respectful social-ecological relationships for the effective management of CE was also discussed by all groups.

Participants repeatedly recognized the need for multiple types of collaborative partnerships to support bold actions that would address CE, but also consistently expressed frustrations related to the challenges of working across ontological, institutional, disciplinary, cultural, and other divides. Necessary partnerships included scientists, other researchers, iwi/Māori, planners, managers, and other practitioners. These transdisciplinary interest groups were expected to collaborate across interconnected systems and scales; stakeholders and Iwi/Māori developing appropriate governance arrangements; and Treaty partners and the Crown developing co-governance and co-management strategies. Participants acknowledged that this work would necessarily be underpinned by the principles of the Treaty of Waitangi, particularly with regard to partnership and rangatiratanga (right to exercise authority). Participants also discussed how individual and collective actions such as changing diet or other consumer habits could have a positive influence on marine futures. The current, relatively short political cycle and associated political system was identified by half of the groups as being at odds with long-term strategizing needed to address CE.

5. Discussion

The workshop described in this paper provided an opportunity for resource managers, planners, iwi/Māori, and other key stakeholders and representatives to share their experiences of managing CE and explore possibilities for future improvements to the system. Over the course of the day, participants proposed and debated the nature of the drivers and challenges associated with the management and governance of CE, as well as a range of ways forward. The need to establish collaborative networks that enable collective thought and action across boundaries was repeatedly emphasized. This spirit of interconnectedness, complexity, and collaboration is evident across the themes and categories that emerged from the data (Table 3 and Appendix C). Martin & Mirraboopa's (2003) theoretical framework was adapted to highlight this range of different, but interwoven, knowledges, values, and actions (and actors) that could be positioned to address CE in the future. This framework supports the inclusion of a range of protocols in our approaches to cumulative effects (Whyte et al., 2016), rather than privileging one over another. The emerging opportunities theme was added to the suite of coding themes to emphasize the actively changing nature of drivers and approaches to CE.

5.1. Knowledges

Knowledge was a key unifying theme that emerged from the workshop. Participants demonstrated a complex and nuanced conception of the kinds of knowledge(s) that are needed to address CE, which led to a re-framing of the literature-based scientific assessment and decision-making theme during the analysis of the data (Table 2). While there was a common focus among the literature and the workshop discussions on data and information (especially baselines and monitoring) (Prahler et al., 2014), scale (Therivel and Ross, 2007), and uncertainty (Rouse and Norton, 2010), participants also discussed the need for an understanding of economics, the role of education, and the position of mātauranga Māori in guiding long-term approaches to CE.

Some participants questioned the singular authority of scientific assessments, and debated how other types of knowledge, indicators, and values could be included in future CE assessments. Our literature review did not reveal this debate to be a common feature of current CE literature, although indigenous and local knowledge is increasingly considered a key element in resource management (Parsons et al., 2017; Whyte et al., 2016).

The knowledge theme that emerged from the workshop is therefore inclusive of a range of knowledge systems and ways of knowing. This theme incorporates elements needed to establish what is known about CE, including considerations of ontologies, understanding, context, processes, methods and information. We posit that social-ecological systems-based knowledge may provide some of this overarching structure, but the methods used to assemble such different types of data and information are not well understood (Brown, 2010). We used transdisciplinary research methods in our workshop (e.g. Pohl and Hadorn, 2007) to open a space for mātauranga Māori and other perspectives to voice and share knowledge and practices regarding managing CE in the marine environment. Those present at the workshop heard stories that demonstrated how CE had become more complex and noticeable compared to what was experienced by previous generations. In thinking about the kind of future that would be left for our children and grandchildren, the prospect of accepting the status quo was deemed untenable. In this context, the responsibility of the Crown to fulfil obligations to Treaty partners was considered fundamental to efforts to re-imagine the governance arrangements and management approaches for CE, but examples of how this will actually be done were not discussed at length.

5.2. Values

The values theme includes the establishment of relationships, connections, and associations among elements of CE. These connections are fundamentally respectful, rightful, and relational. They may also be aspirational, and are principles or standards of behavior that seek to guide appropriate actions. Published literature on CE frequently describes the importance of biophysical connectivity and institutional collaboration in generating effective CE governance and management (Halpern and Fujita, 2013; Lundquist et al., 2016; Murray et al., 2014), but rarely touches on the aspirational or negotiated elements of these relationships. Participants began to articulate these relationships over the course of the workshop. Reflecting on the imaginary worlds of the scenarios in Session 3, they attempted to negotiate their relative priorities in the present day. Particularly in Sessions 2 and 3, which were designed to foster aspirational and action-oriented discussions, participants described the need to encourage and support respectful and balanced social-ecological relationships in ways that are similar to other social-ecological literature (Benham and Daniell, 2016). Frequently cited qualities such as adaptiveness, collaboration, holistic and intergenerational thinking, leadership, trust, and experimentation (Table 3), generally align with an ecosystem-based management approach in which governance arrangements are adaptive and able to respond to shocks and surprises (Thrush et al., 2016).

In discussing the role of science, participants were often, but not always, referring to an organized knowledge system that was inclusive of other ways of knowing such as mātauranga Māori or local knowledge. As described elsewhere, participants sought to situate science within a complex of connections, relations and practices, each associated with varying degrees of power, expertise, and authority (Van Kerkhoff and Lebel, 2015). However, the role of mātauranga Māori in relation to CE was described generally, rather than clearly defined, suggesting that this is an emergent topic in need of more work. Similar to other studies that recognize the need for connectivity to address CE (e.g., Mach et al., 2015), participants focused on connecting science to policy; interactions between marine- and land-based sciences; and connecting systems that extend from the mountains to the sea.

Using "relational values," defined as personal or collective well-being derived from relationships among humans and nature, has been suggested elsewhere as a holistic approach to social-ecological system valuation (Chan et al., 2016). In future work in Aotearoa NZ, an example of relational values could be drawn from the aspirations and practices of kaitiaki (steward or guardian) enacting kaitiakitanga in place. This relationship is defined through cultural practices and protocols and protected by legislation that takes into account the Treaty of Waitangi. Where kaitiakitanga is included in planning, decision making, and management of natural resources, contributions can be made towards the evolution and enhancement of sustainable management goals and practices (Henwood and Henwood, 2011; Jollands and Harmsworth, 2007).

5.3. Actions

The actions theme expands beyond management approaches to include ways to maintain or improve the relationships among elements or entities related to CE (e.g., behaviors, actions, frameworks, laws, rules, and regulations). The actions most frequently discussed at the workshop tended to have a regulatory or governance focus, possibly because many participants were employed at central, regional, or local government agencies (14 representatives out of 44, Table 1). Some industry representatives also expressed a desire for clear regulations and standards that would provide businesses with the confidence to invest in sustainable resource use and enable them to improve their social license to operate. This approach has been described as central to protecting Aotearoa NZ's "100% Pure" brand (McGinnis, 2012). Several groups also discussed non-regulatory actions such as dietary or consumer choices that could be made by communities, iwi/Māori, and industries to address CE, thus creating a space for different actors to play a role, and expanding the concept of actions beyond the construct of management and governance regimes.

The need for integrated, adaptive, and/or collaborative actions across institutional boundaries to address CE was emphasized by all groups. Specifically, the need for a national set of standards and institutional changes that would support these standards and connect across scales was discussed repeatedly in relation to improved CE outcomes. Ways to operate outside of short-term political cycles were also debated. These conversations outlined a desire for supported, structured, and ongoing interagency collaboration to develop constructive solutions that will address CE in the marine environment (Lundquist et al., 2016; Thrush et al., 2016). These discussions widely included agreement that Māori interests, values, and mātauranga would be acknowledged and respected with guidance from the Treaty of Waitangi, though the specifics of how this would play out were not described in depth. These findings are consistent with other literature that has identified a need for a national conversation regarding how to devise a fair and effective governance model for all New Zealanders (Webster and Cheyne, 2017).

5.4. Emerging opportunities and study limitations

In the spirit of experimentation, many creative ideas were discussed during the workshop in an effort to develop a more robust system for addressing CE. For example, co-governance and co-management arrangements between Treaty partners and the Crown are still emerging; these arrangements have the potential to make a lasting impact on how CE are understood and managed in Aotearoa NZ. Other opportunities to address CE will likely emerge because of Treaty settlements and the increasing utilization of undeveloped Māori resources to grow the economy. Future efforts to address many of the challenges and concerns highlighted by workshop participants may benefit from the utilization of co-productive approaches (Van Kerkhoff and Lebel, 2015), which consider the legitimacy and authority among a range of knowledge cultures and encourage the identification of strengths and weaknesses in science and governance arrangements and networks (Bodin, 2017).

This study has produced some intriguing findings, but these may have been influenced by the study design (e.g., introductory article or presentation) or other elements beyond the control of the researchers (e.g., experience or education of participants). Additionally, the research was designed to encourage open and honest discussions among a diverse group of participants, but this goal is challenging to achieve in a short period of time due to the need to develop trust (Harris and Lyon, 2013). Social factors such as power relationships can also influence research outcomes (Le Heron et al., 2016). To control for these influences and limit these risks we have provided as much context and transparency in our reporting as possible, while also maintaining the confidentiality of workshop participants.

6. Conclusions

A variety of strategies regarding how to address cumulative effects were offered by the participants assembled at the workshop described in this paper, especially the need for collective thought and action across boundaries. Examples ranged from supporting the inclusion of different knowledges and values in the development of understandings about CE; to the establishment of shared, long-term visions and goals for Aotearoa NZ's coastal and marine areas; to developing a set of national standards or guidelines that outline how to assess and address cumulative effects. Each tactic has challenges and opportunities that can be articulated and acted upon, but this requires respectful discussion, study, planning, resourcing, and time. Workshop participants took the first steps along the path of co-production by investing their time and participating in conversations that occurred across institutional, cultural and disciplinary boundaries. The SSNSC provided an opportunity to begin to address CE, and the collaborative, interdisciplinary structure of this workshop provided a space in which insights about how to address CE could be conceived, aired, and supported. Many of the findings described in this paper are applicable to ecosystem-based resource management generally, but they are also grounded in a specific set of circumstances and institutions that can be influenced to improve the management and governance of CE in Aotearoa NZ, and internationally relevant for managing CE, thereby making a contribution across a range of scales.

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Appendix A

Karakia

Maiea Maiea
Maiea te tupua maiea te tawhito
Maiea e te kahui o nga ariki
Maiea te kahui o nga taniwha
Tawhiwhi ki nga atua
Ko ranginui ki runga
Ko papatuanuku ki raro
Kaupare atu nga kino o te wa
Kaupare atu nga poke o te wa
Kia whakawatea te ara takatu o tanewhakapiripiri
Tena i ana ara takatu o tawhaki te wananga, tawhaki te waiora
Unu hia unu hia tenei te pou o Tupuanuku,
Unu hia unu hia tenei te pou o Tupuarangi,
Ka whakamaua ki uta
Ka whakamaua ki tai
Tuturu whakamaua kia tina,
Tina haumi e, Hui e, taiki e!

Explanation: The karakia (incantation) that opened the workshop described in this paper is an expression of the whakapapa (genealogy) of some of the major changes that have occurred during the time of creation according to Māori (indigenous peoples of New Zealand). This karakia holds as an enduring example of the way in which Māori recorded the changes in the world around them, understood the interconnectedness of their world, and expressed cumulative effects in a way that is both unique and imperative to consider in an Aotearoa New Zealand setting.

Appendix B

Scenario questions

The same questions were asked in Breakout Sessions 1 and 2 to create opportunities for a comparative analysis of the data. Breakout 3 asked different questions to encourage consideration of how to prepare for a range of futures.

Session 1 questions

1. What is your experience in dealing with CE? (Icebreaker question − important for note takers to capture answers so that some conclusions may be drawn later between institutional knowledge and experience and complexity and nuance of ideas)
2. Identify the activities and processes contributing to cumulative effects in this scenario. (What are the driving forces shaping your issue?). How do you think cumulative effects contributed to this future?
3. What elements are relatively certain? What things are unpredictable?
4. How can the threats posed by the scenario be managed or mitigated? How can opportunities be realised?

5. What are some *indicators* that would hint that this scenario may have been about to unfold? (e.g. canary in the coal mine)

Session 2 questions *(same as Session 1 questions 2–5)*
Session 3 questions

1. What are some of the commonalities and differences in terms of CE across these scenarios? e.g. probably similar kinds of stressors but handled differently, might be around tighter regulatory controls vs. market mechanisms.
2. What actions, policies or institutions do you need to get a handle on CE? Identify what they are − new legislation? More data? Would you mitigate now, adapt later, do some kind of combination?
3. How can we create bold policies or institutions that can deal with CE in both of those futures? What processes are needed e.g. collaborative approaches to planning and decision making; benevolent dictatorship?
4. Who can help this happen and how? Responsibility might include development of policies, implementation, monitoring, research, so will likely cover more than one actor. What organizations? Is there a role for iwi? Industry? Community?
5. What support is needed? Data? Information? Institutional support? Reconfiguration of governance and management structures? Resourcing? Science?

Appendix C

Topic category name	Number of sources	Number of references
Knowledges		
● Biodiversity	2	4
● Climate change	6	19
● Data and information	5	13
○ Baselines	4	12
○ Monitoring	4	14
● Economics	6	32
● Education	6	18
● Indicators	3	5
● Invasive spp	3	3
● Intensive industries	5	16
● Local & contextual	2	6
● Mātauranga Māori	4	7
● Multi-cultural inquiry	5	13
● Population	4	10
● Refugees	5	7
● Scale	5	13
● Uncertainty	5	17
○ Shock, surprise & tipping points	5	15
Values		
● Adaptive	6	40
● Capacity	4	5
● Collaboration	6	26
○ Public-private partnerships	2	2
● Communities & Maori, Role of	5	12
● Connectivity	6	31
○ Global integration	5	15
● Consumer, Role of	5	5
● Creativity	2	2
● Diverse perspectives	3	4
● Engagement	6	16
● Equity & Equality	4	12
● Experimentation	4	12
● Freedoms & Rights	5	14
● Holistic perspective	6	25
○ Intergenerational thinking	5	19
● Industry, Role of	5	13
● Informed publics	5	13
● Kaitiakitanga	2	4
● Leadership	6	23
● Ownership & Responsibility	6	16
● Power	4	13
● Proactive	5	8
● Representation	2	4

● Science, Role of	6	33
● Shared vision, goals & values	6	52
● Social values	6	23
● Trust	6	19
Actions		
● Behaviour change	6	22
● Citizen science	1	2
● Communication	6	14
● Group decision-making	2	7
● Guidelines	4	8
○ National standards	6	23
● Incentives	5	16
● Institutional change	5	17
● Integrated governance	5	19
● Integrated management	6	32
○ Ecosystem-based management	3	6
○ Marine spatial planning	1	3
○ Risk management	3	9
● Investment in science & technology	4	17
● Local governance and management	5	8
● Participatory processes	3	9
● Political system	6	18
● Redistribution	2	5
● Regulation	6	34
● Resourcing	4	10
● Traditional practice	2	2
Emerging opportunities		
● Alternative industries	4	7
● Co-governance & Co-management	4	8
● Sustainable Seas National Science Challenge	2	7
TOTAL NUMBER OF REFERENCES		988

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